3D GPS antenna for an outdoor activities watch

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Brief description

Embedded systems are generally small systems with wireless communication. One of the main challenges of these stand-alone devices is to ensure effective communication despite their small size and very low power requirements. To meet the growing needs of outdoor embedded systems, we have developed an antenna specially adapted to this environment and therefore to the materials present in it.

Key points

In the case of a connected watch, we had to solve two important problems. The first was the weight and thickness constraints imposed by the manufacturer to install a high-performance antenna, the second was related to the time needed for the watch to be synchronized with the GPS signal.

To solve that, we decided to design a specific methodology and used microwave solution. This is why 3D MID (Molded Interconnect Devices) techniques were implemented to fulfill the weight and thickness constraints for this round watch.

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Exploded view of the watch with the integrated antenna. ©Christophe Dupuis

While designing the new antenna we decided to take into account watch materials and shape. We opted also for monopole antenna on 3D polymer substrate which matches with a round watch.

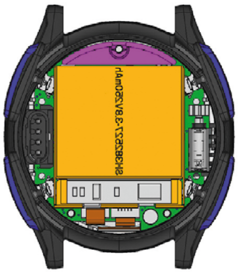
- The first important step is to know precisely the dielectric constants of all materials around the antenna at the frequency of use, in this case GPS.
- The second step is to design an antenna (Picture 1) in the available space and evaluate its performance by simulation. Then it must be physically realized, and its characteristics experimentally verified.

As our simulation software was initially limited, we chose to focus on the importance of electronic details. In particular we focused on the vias of the electronic board to optimize the number of meshes and simulation times. Thus, we evaluated that taking into account the vias had no impact on the results by more than 1% due to the distance with the antenna. The same is true if the signal tracks are replaced by a solid conductive plate.

As the 3D plastic substrate is round, we bent the monopoly on it. Its largest dimension is 20 mm. We then folded the antenna to obtain a frequency of 1.575GHz and adapted it so that at least 2/3 of the energy is transmitted (reflection coefficient threshold at -10dB).

Electrical length of conductive part is 39.38 mm which could be too short to get an efficient antenna, but we used astuteness to lengthen electrical dimension. Antenna resonant frequency is centered at 1.575 GHz and impedance matched at 50Ω with -18dB reflection coefficient; its bandwidth at -10dB from 1.5648 to 1.5828 GHz. Radiation pattern (Picture 2) looked like a monopole one; gain and efficiency are still acceptable, even if antenna is miniaturized: respectively -0.27dB and 67%.

We finally realized it in LDS (Laser Design Structuring) (Picture 3) and measured different versions of it in an anechoic chamber (Picture 4). The experimental results confirmed simulation ones.



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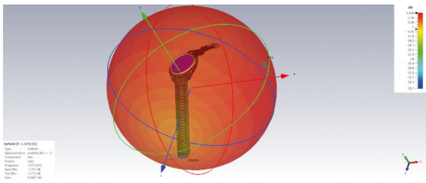

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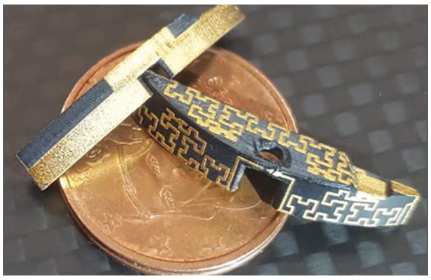

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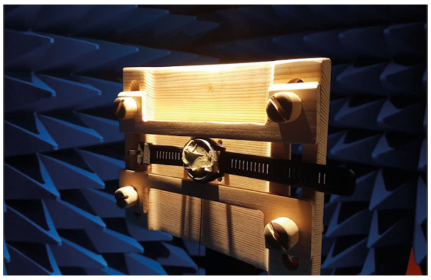

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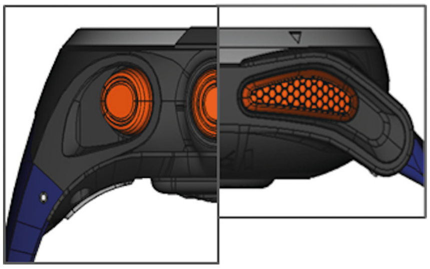

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Output

We solved mechanical problems with EM solution. Indeed, first watch version was too thick and heavy because of ceramic shape and weight. By evaluating antenna close environment, we managed to build a dedicated 3D, small and light antenna.
We validated this methodology (Picture 5).
More than that, this antenna is more efficient than the first one.

Special equipment

We used CST Microwave Studio for 3D design and electromagnetic simulations.

We also used an anechoic chamber to measure antenna's parameters.

Legends

1 - Environment taken into account (watch)
2 - Simulated gain in close environment
3 - Different designs of realized antennas
4 - Antenna's measurements in anechoic chamber
5 - Mechanical impact

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